Water-Supply and Irrigation Paper No. 158

Series { B, Descriptive Geology, 88
0, Underground Waters, 54 }

DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

PRELIMINARY REPORT

ON THE

GEOLOGY AND UNDERGROUND WATERS OF THE ROSWELL ARTESIAN AREA NEW MEXICO

BY

CASSIUS A. FISHER

WASHINGTON
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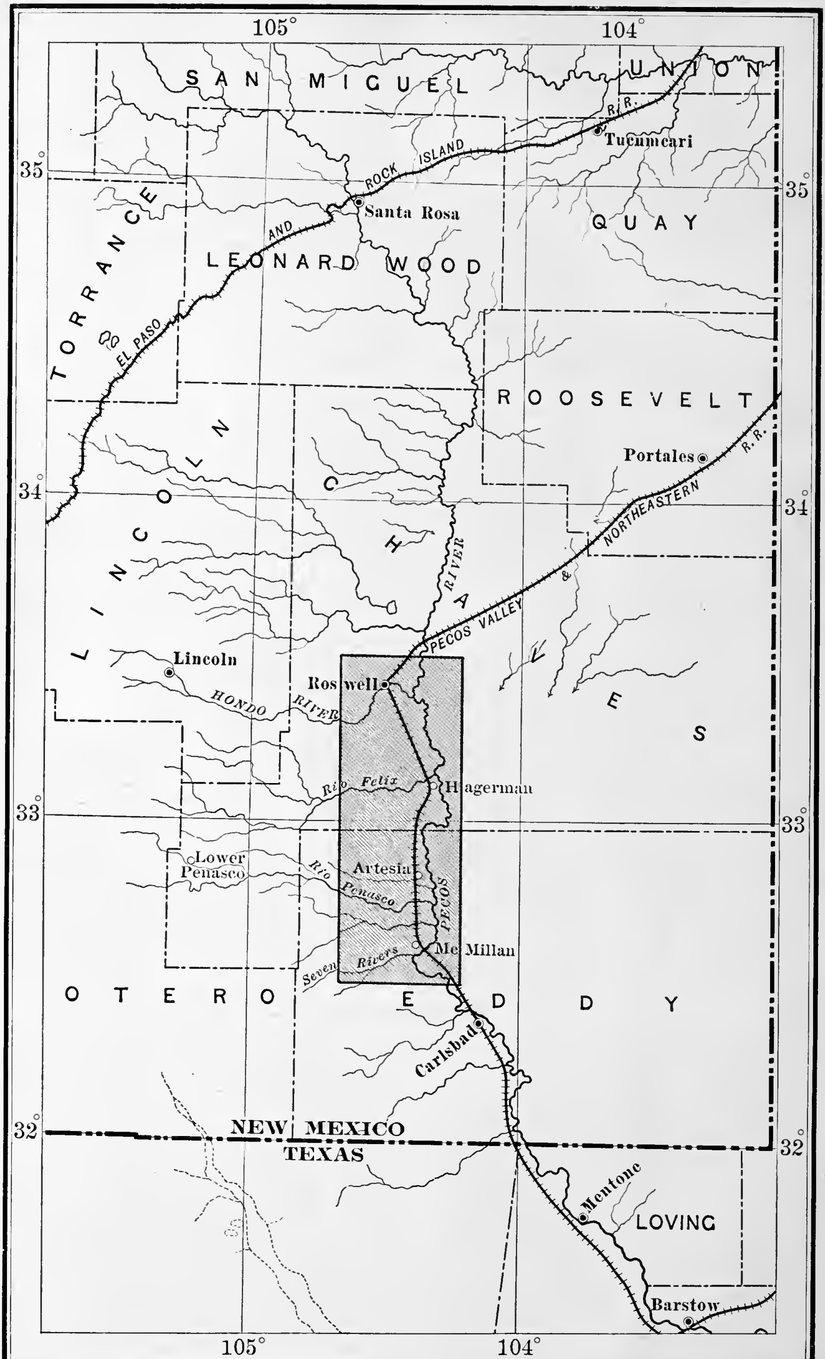


MAP SHOWING GENERAL LOCATION OF THE ROSWELL ARTESIAN AREA.

PRELIMINARY REPORT ON THE GEOLOGY AND UNDERGROUND WATERS OF THE ROSWELL ARTESIAN AREA, NEW MEXICO.

By Cassius A. Fisher.

INTRODUCTION.

The area to which this report relates is located in southeastern New Mexico. It comprises about 1,800 square miles lying along Pecos River and extending from a point 5 miles north of Roswell to below the mouth of Seven Rivers, as shown in Pl. I. In addition to the discussion of the artesian waters, the report includes a brief description of the geology of the sedimentary rocks, their structure, and their relation to the underground waters. The area of flowing wells is indicated on the map, Pl. VI, and records of representative wells are given, which are intended to illustrate the character and succession of the water-bearing beds) Information respecting surface waters available for domestic and irrigation purposes and a brief description of the climatic and agricultural features of the region are also given.

The investigation was conducted under the direction of Mr. N. H. Darton.

The writer was assisted in the field by Messrs. E. M. Mitchell and E. Patterson, and these gentlemen obtained a portion of the well data upon which this report is based. The systematic measurement of well pressures was carried on under the direction of Mr. W. M. Reed, district engineer of the Reclamation Service, who has done much to promote the work. The chemical analyses of the surface and artesian waters have been kindly furnished by Mr. E M. Skeats, of El Paso, Tex., and the paleontological collections have been examined by Dr. G. H. Girty. I am indebted to Messrs. Hagerman, Goodart, Phillips, Hortenstein, Spurlock, Hale, and others for information concerning artesian irrigation.

An excellent report on the soils of the Roswell basin by Messrs. T. H. Means and F. D. Gardner was used in the preparation of this report.

TOPOGRAPHY.

Relief.—The topographic features of the Roswell basin present little variety. Across the east side of the district there are irregular bluffs rising 200 to 300 feet above Pecos River, while to the west the surface rises gradually toward the high limestone plateau bordering the Capitan, Sierra Blanca, and Sacramento mountains. The region has an average elevation of 3,600 feet above sea level. The highest portion is along the west side of the district, where the altitude is about 4,000 feet. In the southeast corner the altitude is about 3,200 feet. Near the junction of the North and South forks of Seven Rivers there is a high bluff having a north-facing escarpment, which rises high above the valley of the South Fork, and on the north side of Eagle Draw is a small but prominent plateau.

Drainage.—The principal drainage channel is Pecos River, which enters from the north and flows in a southerly direction across the district. The flow is not large, but it carries a small amount of water during the entire year. There are a number of tributaries from the west, the largest being the Hondo, Felix, Penasco, and Seven rivers. Hondo and Penasco rivers, perennial streams throughout their upper courses, have their sources high on the

slopes of the Capitan, Sierra Blanca, and Sacramento mountains. The Felix and Seven rivers rise in the limestone plateaus lower down, and drain a much smaller area. Hondo River east of Roswell is joined on the north by North Spring and Berrendo rivers, and on the south side near its mouth by South Spring River. These streams are fed by springs, and they carry abundant water at all seasons. There are also several small intermittent streams which enter Pecos River. Those from the west are Gardners Arroyo, Fourmile Creek, Eagle Draw, Cottonwood Creek, Walnut Draw, and Zuber Hollow; those from the east are Comanche Draw and Long Arroyo.

Lakes.—At the heads of North and South Spring rivers and Middle and South Berrendo rivers are lakes of moderate size. These lakes are fed by a number of small springs, which derive their water mainly from the unconsolidated deposits underlying Hondo, Blackwater, and Eden valleys. Water rises to the surface in the lower courses of Felix River, Cottonwood Creek, Penasco River, Gardners Arroyo, and North and South Forks of Seven Rivers. In the vicinity of Lake Arthur, Hagerman, Greenfield, and Dexter, and north along the east side of the Northern canal there are lakes fed in part by springs and in part by seepage from the Northern canal.

On the east side of Pecos River, about 12 miles southeast of Roswell, are several deep lakes lying along the base of the gypsum bluffs, which are locally known as the "Bottomless Lakes." Dimmit Lake, the largest of these, is situated at the head of a short ravine about 2½ miles from Pecos River. Near the mouth of this ravine, on the north side, is Dee Lake, and along the base of the bluffs for some distance to the north several smaller lakes occur. The location of these lakes is shown on the geologic map, Pl. IV. They have probably been formed by flood water from the high slopes to the east, which, in flowing over the exposed gypsum ledges at the edge of the bluffs, has dissolved the gypsum and formed subterranean passages that now extend to some of the shallow artesian flows in Pecos Valley. A view of one of the "Bottomless Lakes" is shown in Pl. III, *A*. The water from some of these lakes is used for irrigation.

OUTLINE OF GEOLOGIC RELATIONS.

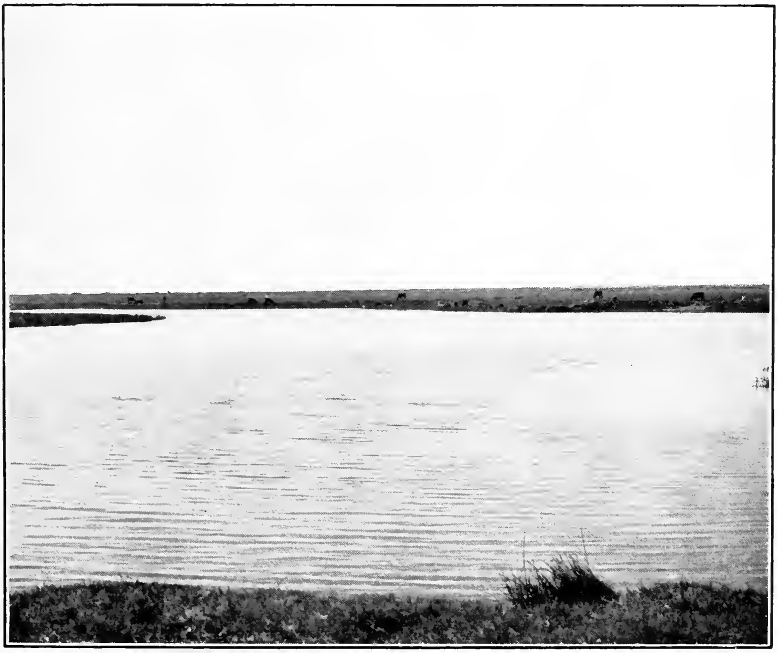
GENERAL STATEMENTS.

The rocks of the district comprise limestone, sandstone, clay, and gypsum which are believed to be of Permian age. Overlying these deposits throughout the Roswell basin are extensive sheets of sand, gravel, clay, and silt, probably of Quaternary age, which have been deposited in successive terraces between Pecos River and the high limestone slopes to the west. The so-called Permian series of this district consists of an upper red bed member of gypsum, red sand, limestone, and clay 600 to 800 feet thick, forming the high bluffs along the east side of Pecos River and underlying the recent deposits of Pecos Valley, and a lower member of massive limestone, clay, and gypsum of undetermined thickness, which constitutes high rugged slopes to the west. Overlying the red-bed division east of Pecos River is a reddish-brown sandstone about 100 feet thick, which may be of Cretaceous age. No subdivisions have been made of the probably Permian rocks in this region in the present reconnaissance.

PERMIAN (?) SERIES.

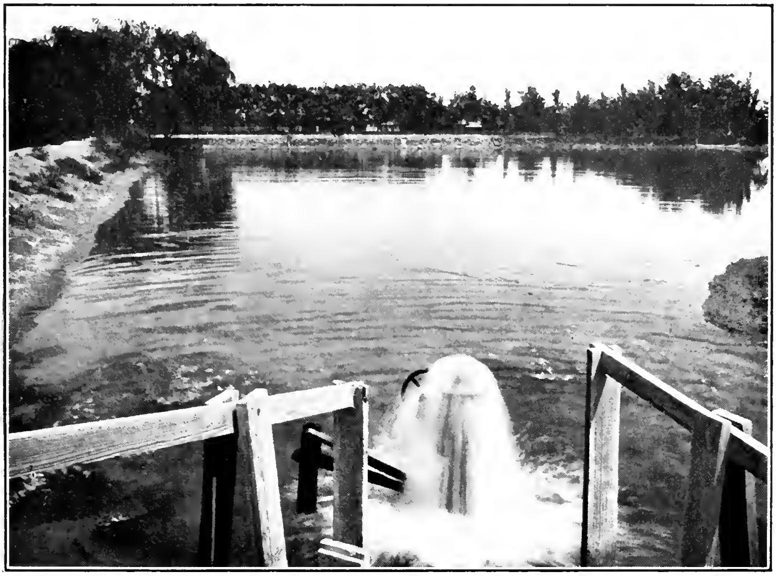
Red-bed division.—These rocks consist of alternating beds of gypsum, red sand, and clay, with an occasional layer of dark-gray, compact limestone. The gypsum predominates and usually occurs in beds about 10 feet thick. It is often found, however, in thinner layers, interbedded with clay and limestone. The red beds are provisionally placed in the Permian, although no fossils have been found in them. They are not shown separately on the geologic map (Pl. IV), but are represented with the underlying massive limestones. The upper part of the beds is well exposed in the bluffs along the east side of Pecos River, where a number of sections have been measured. These sections are as follows:

A. HEAD OF NORTH SPRING RIVER.



B. HEAD OF SOUTH SPRING RIVER.

A. VIEW OF "BOTTOMLESS LAKES," EAST OF PECOS RIVER



B. ARTESIAN WELL AND RESERVOIR EAST OF SOUTH SPRING, NEW MEXICO.

Sections of gypsum bluffs along the east side of Pecos River, New Mexico.

	Feet.
East of Roswell:	
Alternating layers of gypsum and red sand, with an occasional layer of limestone	50
White gypsum	6
Red sand	6
White, thin-bedded gypsum	10
Red sandstone containing thin layers of limestone	24
White gypsum	5
Red sand	13
Gypsum	10
Red sand	3
Gypsum	8
Red sand	8
Gypsum	4
Greenish-gray sandstone	25
Gypsum	6
Total	178
At Dimmit Lake:	
Gray, sandy limestone	20
Alternating layers of gypsum and red and green clay, with an occasional bed of porous limestone	100
Gypsum	4
Red clay	2½
Gypsum	18
Alternating layers of gypsum and red clay	6
Gypsum	11
Alternating layers of gypsum and red sandstone	6
Gypsum	9
Red clay	1
Gypsum	10
Alternating layers of gypsum and red clay	15
Gypsum	5
Red clay	1½
Gypsum	10
Red clay	7
Alternating layers of gypsum and red clay	8
Gypsum	6
Red clay, with thin layers of gypsum	3
Gypsum	6
Total	249
Eight miles northeast of Artesia:	
Gray, compact limestone	5
Gypsum and red, sandy clay in alternate succession	65
Red, sandy clay	10
White, massive gypsum	15
Red, sandy clay	5
White gypsum	10
Gray limestone	5
Gypsum	18
Red clay	12
Gypsum	5
Total	150
About 2 miles southeast of the mouth of South Fork of Seven Rivers:	
Massive, gray limestone	35
Gypsum and red sandstone in alternate layers, with an occasional limestone ledge	50
Gypsum, thin-bedded porous limestone, and red sandstone arranged alternately, the gypsum predominating	150
Gypsum, with thin layers of gray limestone	50
Total	285

Limestone division.—The massive limestone beds underlying the so-called Permian red beds of this region consist mainly of gray, compact limestone, with layers of soft sandstone, clay, and gypsum. In the upper part the limestone is more or less thin-bedded and

porous, and contains many sandy layers. From these beds some of the strongest artesian flows in the Roswell basin are obtained. Limestone outcrops along the west side of the district, and farther to the west forms high rugged plateaus, extending toward the mountains. Fossils are not abundant in the formation, but in one locality northwest of Roswell a number were collected, which consisted mainly of *Schizodus* and *Pleurophorus*, preserved as casts. According to Doctor Girty the fauna and lithology of these specimens suggest the highest Carboniferous beds or the Permian of the Mississippi Valley in Texas.

To the east of the Roswell district the high plains are traversed by dikes of igneous rock. One of these dikes extends into the area in the northeast corner, but passes beneath the surface at a point about 5 miles east of Pecos River. Its location is shown on the geologic map (Pl. IV). The dike is about 35 feet wide, and consists of a light-colored rock, which is much decomposed on the surface.

Extending across the southeast portion of the area, from below Lake McMillan to the high bluffs east of Artesia, is a narrow zone in which the sedimentary rocks are more or less metamorphosed, so that in the crevices considerable mineralization has taken place. Copper is the principal mineral, occurring mainly as the carbonate and oxide. Some prospecting has been done in the hills south and east of Artesia, but no paying ore has been discovered.

CRETACEOUS (?) SYSTEM.

The sandstone overlying the Permian (?) red beds along the east side of the district is possibly, as above stated, of Cretaceous age. A few fossil plants were found in these beds, but they were too fragmentary to be determined. The distribution of the formation was not ascertained. It consists of massive, reddish-brown sandstone in beds of varying thickness, with an occasional layer of light-gray sandstone. The material is coarse grained and cross-bedded throughout, and often weathers into rounded forms. The following is a section of the sandstone near Petty's windmill, about 15 miles northeast of Roswell:

Section of sandstone overlying Permian (?) red beds near Roswell, N. Mex.

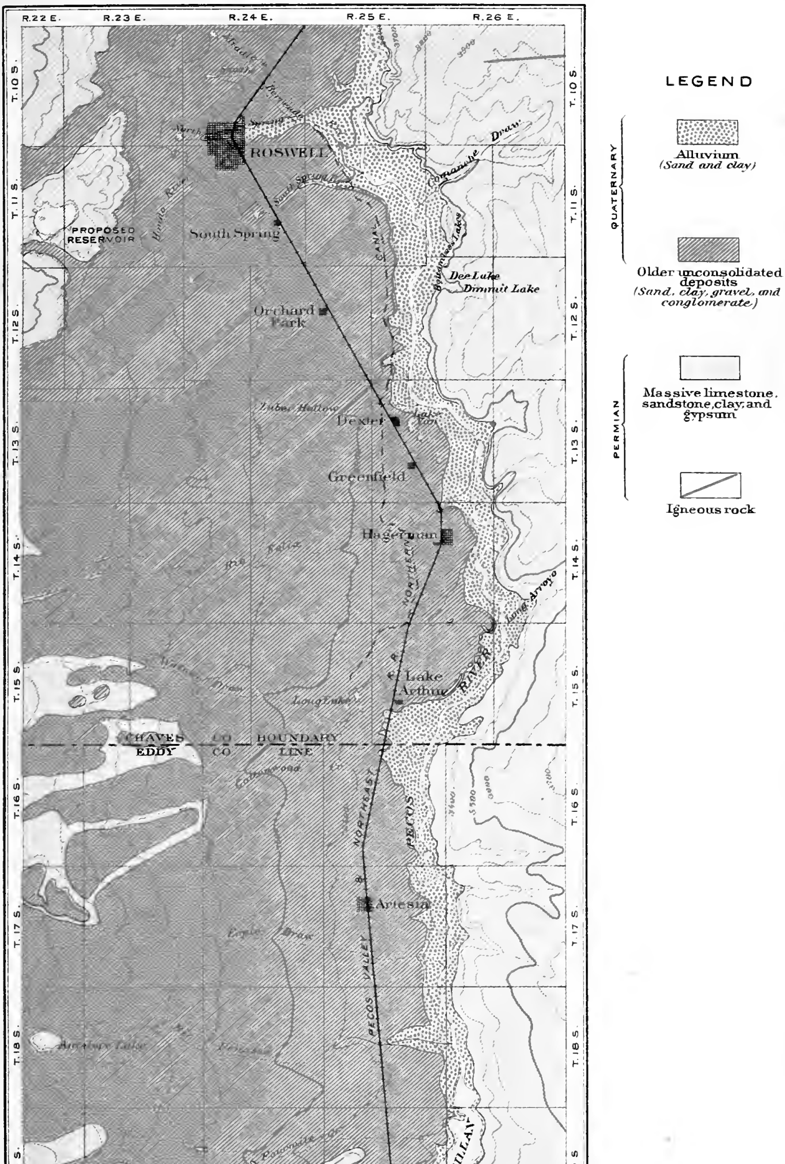
	Feet.
Reddish-brown, cross-bedded sandstone	40
Brown, massive sandstone	6
Lighter brown, massive sandstone, somewhat cross-bedded	10
Gray, coarse-grained sandstone	1
Reddish-brown sandstone	18

QUATERNARY SYSTEM.

The formations of the Quaternary period cover an extensive area in the Roswell basin, comprising approximately 1,200 square miles. They occupy the entire central portion of the basin, and extend far up the limestone slopes to the west. These deposits are mainly of two kinds—the alluvium of the river valleys and the unconsolidated material of higher levels.

Alluvium.—The alluvium is confined mainly to Pecos River Valley, although small areas occur along all the larger and many of the smaller streams. It is a light-colored, fine-grained material, consisting mainly of sand, gravel, and clay, with a small amount of organic matter. In the lower portions of the valley the soil contains much "alkali," often sufficient to render it unfit for cultivation. There are many small lakes along the river bottom, and the lowlands are generally swampy. On the east side of Pecos River, from a point opposite Dexter to beyond Comanche Draw, there are several springs, which have built cones of spring deposits 6 to 10 feet high.

Hondo, Felix, and Penasco rivers have built small flood plains along their lower courses which are perceptibly higher than the surrounding region. The alluvium along these streams varies somewhat in character, but it is generally of a light-gray color, and consists of gravel, sand, silt, and clay, covered by a fertile soil. The fertility is due to the presence of fine silt brought down by the flood waters from the high mountain rgeions. According



RECONNAISSANCE GEOLOGIC MAP OF THE ROSWELL ARTESIAN BASIN, SOUTHEASTERN NEW MEXICO

BY C. A. FISHER

Topography compiled from railroad data and barometer readings

Scale

2 0 2 4 6 8 10 miles

Contour interval 100 feet

1905

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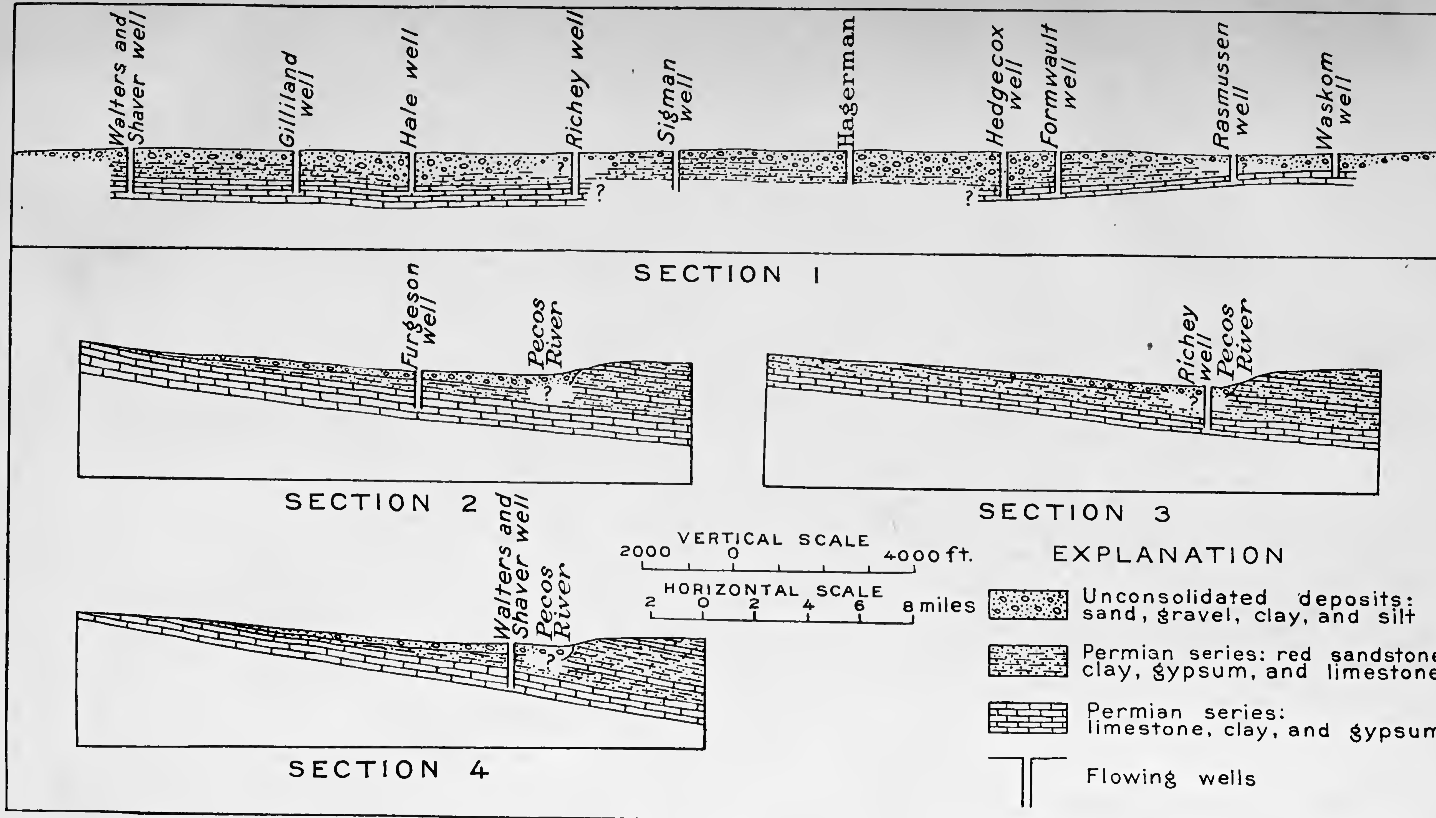


GEOLOGIC SECTIONS ACROSS THE ROSWELL ARTESIAN BASIN.

to Mr. T. H. Means the alluvium of Hondo Valley contains more plant food than that of the Nile in Egypt. The following analyses are taken from Mr. Means's report:[a]

Chemical composition of Hondo and Nile sediment.

Constituent.	Hondo mud (Skeats).	Nile mud (Mackenzie).	Constituent.	Hondo mud (Skeats).	Nile mud (Mackenzie).
Insoluble matter and silica	43.6	58.17	Soda	....	.62
Iron oxide and alumina	21.4	24.75	Sulphuric acid	1.96	.20
Oxide of manganese	....	.09	Phosphoric acid	.3	.21
Magnesia	2.1	2.42	Carbonic acid	....	1.55
Lime	5.7	3.31	Organic matter	9.8	8.00
Potash	1.19	.68	Nitrogen in organic matter	.32	.12

Unconsolidated deposits.—These deposits consist mainly of sand, gravel, and clay. The sand is of light-gray color, medium to fine grained, the clay more or less sandy, and the gravel a moderately coarse variety. The gravel is often firmly cemented by calcium carbonate, and local deposits of gypsum and a calcareous material known as "caliche" occur throughout the formation. According to well records the thickness of the formation varies considerably in different parts of the basin. In several deep wells around Artesia coarse gravels were encountered 500 to 700 feet below the surface. At Roswell and in the lower part of Hondo Valley unconsolidated sediments are 150 to 300 feet thick, and in Seven Rivers Valley they are probably thicker. In John Richey's well, 8 miles northeast of Artesia, a gravel bed, apparently the base of the unconsolidated sediments, was penetrated at a depth of 134 feet. At Sigman's well, near Lake Arthur, according to the driller's statement, the unconsolidated deposits are only a few feet thick, and about 3 miles northeast of Lake Arthur the red, sandy beds of the Permian (?) are exposed.

ARTESIAN WATER HORIZONS.

There are several artesian horizons in the formations underlying the Roswell basin. Flows of moderate volume are found in the sandstones of the upper member of the Permian (?) series and in the overlying unconsolidated deposits, but the strongest are from porous limestones interstratified with beds of sand, which constitute the upper part of the massive limestone division.

EXTENT OF ARTESIAN AREA.

The Roswell artesian basin is about 60 miles long and has an average width of 11 miles. At the north end it is relatively narrow, but to the south it widens somewhat. It comprises about 650 square miles, the greater part of which lies along the west side of Pecos River. The area of flow is shown on Pl. VI.

In the vicinity of Roswell the head of artesian water, as determined both by practical tests and by the pressures of a number of flows in the town of Roswell, is sufficient to raise water to an altitude of 3,586 feet above sea level, the exact elevation of the water level in the head of North Spring River. In order to ascertain the western limit of the area of flow south of Roswell a line of levels was surveyed, under the direction of Mr. W. M. Reed, district engineer, from the head of North Spring River as far south as Eagle Draw. From there to Seven Rivers the western boundary of the artesian basin was ascertained mainly from evidence of wells in the adjoining lowlands. It is possible that the artesian head increases to the west and that flows might be obtained higher up the slopes than is indicated on the artesian water sheet, especially in the valleys of Felix River, Cottonwood Creek, and Penasco River, but there appears to be no definite evidence of this. The eastern limits of the artesian area

[a] Means, T. H. and Gardner, F. D., Soil survey in the Pecos Valley: Field operations of Bureau of Soils, 1899, U. S. Dept. Agric., Rept. No. 64. 1900, p. 49.

are indicated by moderately high bluffs, which follow the general course of Pecos River across the entire district.

About 15 miles northeast of Roswell on the south side of Salt Creek are a number of springs that furnish considerable water. It is possible that shallow flowing wells would be obtained in the lowlands of Salt Creek Valley below these springs, but no investigation was made of this region. At Stockpens, about 13 miles northwest of Roswell and a short distance south of the mouth of Salt Creek, a deep test well was being sunk at the time this investigation was made. The boring had reached a depth of 900 feet without obtaining a flow, but it was the intention of the well owners to continue to a depth of 1,000 feet. The head of artesian water in the northern part of the Roswell basin, as calculated from the pressures of flows in the vicinity of Roswell, is not sufficient to bring water to the surface in wells at Stockpens.

There is a deep well at Portales, N. Mex., in which a flow was obtained at a depth of about 400 feet. A record of this well is as follows:

Record of well at Portales, N. Mex.

	Feet.
Soil	0– 4
Gypsum	4– 8
Red, sandy clay	8– 20
White limestone	20– 32
Red, sandy clay	32– 48
White limestone	48– 88
Red clay	88–188
"Flint rock"	188–189
Coarse gravel and sand	189–219
Red clay	219–297
White sandstone	297–309
White sand and clay in alternate layers	309–399

WELLS AND WELL PROSPECTS IN ROSWELL ARTESIAN BASIN.

GENERAL CONDITIONS.

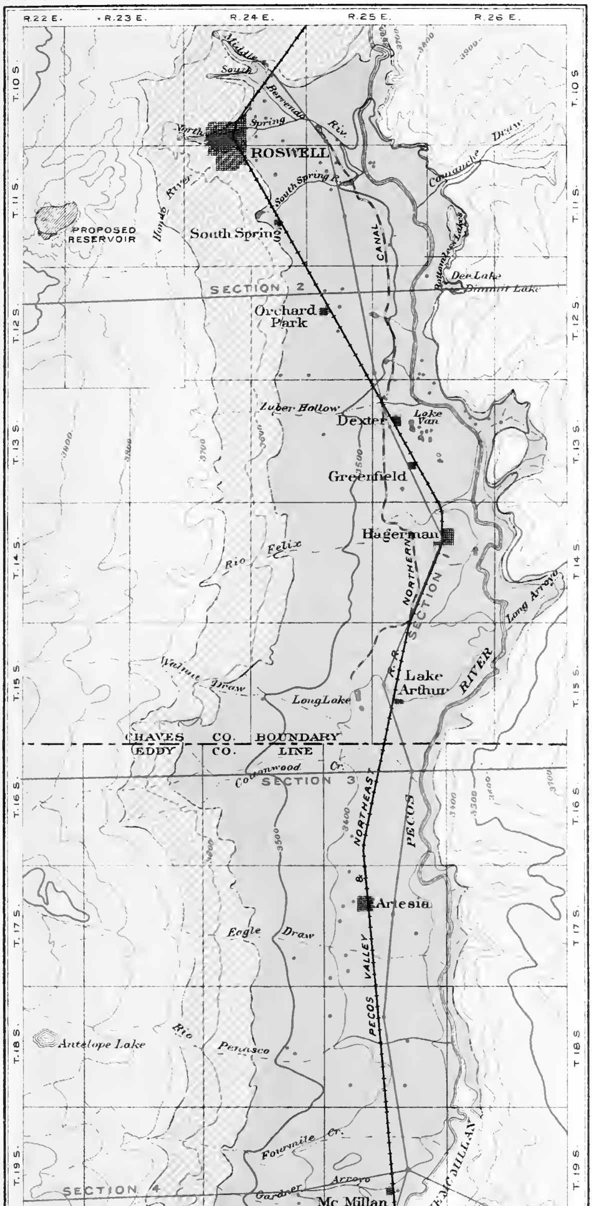
Flowing wells were first obtained in the Roswell basin about ten years ago and for a number of years thereafter development was confined chiefly to this immediate vicinity. During the last two years, however, strong flows have been obtained near Artesia, and at present this part of the basin is receiving the greatest development. Owing to the rapid progress in well sinking throughout the Roswell basin it is difficult to give a complete list of the flowing wells. Information of about 200 has been obtained, but it is probable that the total number at present exceeds 250. About half of this number are found in Roswell and North Spring River Valley, the extreme north end of the basin.

In amount of flow the wells vary from a few gallons to 1,800 gallons a minute, differing principally with the locality. At Roswell the flow of an average well has been variously estimated at 500 to 700 gallons, while near Artesia the highest flow recorded exceeds 1,700 gallons. The water is used chiefly for irrigation and domestic purposes. In a few cases, however, the presence of sulphur renders it unfit for household use. The Formwaltz well northeast of Hagerman is said to have medicinal properties, but no chemical analysis of the water was obtained.

As the conditions under which artesian water is obtained throughout the Roswell basin show considerable variation, the area in the following discussion is divided into four districts—Roswell, Hagerman, Artesia, and McMillan. The Roswell and Hagerman districts are in Chaves County, and the Artesia and McMillan districts are in Eddy County.

CHAVES COUNTY.

Roswell district.—This district comprises the northern portion of the area of flow included in Chaves County, and, as stated above, it is the district where greatest development has taken place. In Roswell and in Hondo Valley the depths of the wells vary from 150 to 500 feet, the average being 250 feet. To the southeast in the vicinity of Orchard Park flows are



LEGEND

Artesian area

Approximate area of irrigable land in which water would probably rise in deep wells within 100 feet of the surface

Non artesian area

Flowing wells

MAP OF THE ROSWELL ARTESIAN BASIN
SOUTHEASTERN NEW MEXICO
BY C.A. FISHER
Topography compiled from railroad data and barometer readings
Scale
2 0 2 4 6 8 10 miles
Contour interval 100 feet
1905

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obtained at a much greater depth. The formations encountered in sinking a well at Roswell generally consist of unconsolidated deposits for the first 175 feet from the surface. Below this depth drills penetrate bed rock, composed of hard, light-colored limestone underlain by alternating layers of porous limestone and sandstone. The following are records of representative wells in and near Roswell:

Typical well records in and near Roswell, N. Mex.

	Feet.
Record of the Ogle well at Roswell:	
Soil	0– 5
Gravel	5– 30
Blueish clay with layers of gravel	30–150
Greenish-yellow clay with rust-colored bands	150–162
Soft red sandstone (water bearing)	162–170
Red clay	170–174
Gray limestone	174–177
Red clay	177–178
Gray limestone	178–182
Gray limestone, very hard	182–186
Soft gray limestone	186–204
Hard gray limestone	204–218
Light-gray, porous limestone (water bearing)	218–226
Limestone and sandstone in alternate layers (water bearing)	226–242
Record of the Waskom well, SW. ¼ sec. 32, T. 10 S., R. 25 E.: [a]	
Soil	0– 5
Sand and gravel	5– 15
Yellow clay	15– 40
Clay and decomposed gypsum	40– 70
Sandstone, coarse yellow sand, and gravel in alternate succession	70–360
Limestone and sandstone in alternating layers, the limestones predominating	360–560
Record of the Rasmussen well, SW. ¼ sec. 21, T. 11 S., R. 25 E.:	
Soil and fine sand	0– 30
Gray sand	30– 40
Gravel	40– 50
Rock and gravel in alternate layers	50– 60
Red sand	60– 65
Gray sand and hard rock in thin layers	65–172
Quicksand	172–212
Red sandstone	212–327
Red sand containing layers of rock	327–400
Limestone	400–560

Partial list of artesian wells in Roswell district, New Mexico.

Name of owner and location.	Depth.	Diameter.	Yield [b]
	Feet.	*Inches.*	*Galls. per minute.*
Anderson:			
SE. ¼ sec. 3, T. 11 S., R. 25 E	60	6	....
Do	60	6	....
Do	58	6	....
Anderson & Skillman, lot 7, block 16, West Roswell	440	4	400
"Bottomless Lake" well, SE. ¼ NW. ¼ sec. 10, T. 12 S., R. 26 E	420	6	....
Bradley & Beal, lot 6, block 53, West Roswell	232	$5\frac{5}{8}$	600
Brink, Fritz, lot 14, block 23, west side Roswell	235	$5\frac{5}{8}$	500
Brown & Creighton, lot 11, block 4, original Roswell	238	$5\frac{5}{8}$	500
Cahoon, E. A.:			
NW. ¼ NW. ¼ sec. 34, T. 10 S., R. 24 E	340	$4\frac{1}{2}$	402
Lot 6, block 21, west side Roswell	229	4	250
Chambers, R. M., lot 4, block 24, original Roswell	244	$4\frac{5}{8}$	600
Champion, D., NW. ¼ NW. ¼ sec. 27, T. 10 S., R. 24 E	330	$7\frac{5}{8}$	300

[a] In this well, located 4 miles east of Roswell, bed rock was reached at a depth of 360 feet.
[b] Mainly estimated.

Partial list of artesian wells in Roswell district, New Mexico—Continued.

Name of owner and location.	Depth.	Diameter.	Yield.[a]
	Feet.	*Inches.*	*Galls. per minute.*
Chaves Co., block 11, Roswell	206	5⅝	675
Church, J. P., lot 8, block 45, West Roswell	270	5⅝	500
Cottingham, J. A., lot 13, block 19, original Roswell	202	5⅝	600
Davis, W. P., SE. ¼ NE. ¼ sec. 7, T. 11 S., R. 25 E	450	5⅝	500
Denning, S. P., lot 8, block 51, west side Roswell	240	5⅝	580
Diamond ice factory, lot 1, block 7, Thurber's addition, Roswell	196	5⅝	700
Dickson, J., northwest corner Washington and 2d sts., Roswell	270	5⅝	660
Dickson, J. M., lot 5, block 52, west side Roswell	198	5⅝	400
Divers, F., lot 2, block 9, west side Roswell	232	5⅝	600
Dunn, G., T. 12 S., R. 26 E	264	6⅝	410
Evans, J F., lot 8, block 28, original Roswell	200	4	250
Elliott Bros., SW. ¼ SW. ¼ sec. 32, T. 12 S., R. 25 E	859	6	612
Faulkner, R. L., lot 10, block 12, west side Roswell	198	5	500
Ferguson, W. M.:			
Lot 10, block 2, original Roswell	255	4½	320
NE ¼ NW. ¼ sec. 15, T. 12 S., R. 25 E	882	6⅝	987
Finley, M. N., SW. ¼ SW. ¼ sec. 3, T. 11 S., R. 24 E	354	7⅝	150
Fitzgerald & Kingston, lot 1, block 17, original Roswell	200	5⅝	600
Fitzgerald, lot 12, block 26, original Roswell	190	5⅝	500
Frank, C. J., lot 9, block 10, original Roswell	202	5⅝	600
Garrett, A. D., lot 1, block 20, west side Roswell	260	5⅝	500
Garst, J., lot 2, block 1, original Roswell	271	3	250
Garst, Julius, SE. ¼ SW. ¼ sec. 28, T. 10 S., R. 24 E	279	6⅝	....
Gaslin, H., lot 10, block 48, west Roswell	242	4½	350
Gaullier, lot 6, block 1, original Roswell	265	5⅝	680
Goodart, J. H., NW. ¼ NE. ¼ sec. 7, T. 11 S., R. 25 E	400	4⅝	600
Hagerman, O., lot 3, block 24, South Roswell	405	5	680
Hamilton, R. S., lot 12, block 14, original Roswell	301	5⅝	800
Hamilton, J., SW. ¼ SW. ¼ sec. 26, T. 10 S., R. 24 E	313	6⅝	400
Haynes, C. W.:			
Lot 7, block 20, South Roswell	310	5⅝	750
Roswell	232	5⅝	750
Do	204	7⅝	750
Do	232	5⅝	700
Henning, J. H., lot 7, block 11, west side Roswell	235	5	400
Hinkle, J., lot 7, block 51, west side Roswell	235	4½	400
Hobson, Lowe & Co., lot 9, block 3, original Roswell	270	5⅝	600
Hortenstein, NW. ¼ SW. ¼ sec. 23, T. 12 S., R. 25 E	840	5⅝	349
Jaffa, N., lot 10, block 3, Thurber's addition, Roswell	200	3	200
Jaffa & Prager, lot 13, block 14, Roswell	380	4	450
Johnson, R. W., lot 7, block 24, west side Roswell	250	5⅝	750
Lawndes, G., NW. ¼ NW. ¼ sec. 35, T. 11 S., R. 25 E	287	....	300
Lea, J. C., lot 5, block 4, original Roswell	230	6⅝	750
L. F. D. stock farm, SE. ¼ NW. ¼ sec. 1, T. 11 S., R. 24 E	383 333	6⅝ 4½	596 100
McCarty, S. S., N. ½ NW. ¼ sec. 14, T. 10 S., R. 25 E	844	5⅝	300
McClenney, M. E., SE. ¼ SE. ¼ sec. 35, T. 10 S., R. 24 E	375	7⅝	600
Marrow & Tannehill, lot 14, block 13, old Roswell	260	5	500
Meeks, W., lot 6, block 28, original Roswell	160	4	250
Miller, J., lot 4, block 30, original Roswell	230	5⅝	580
New Mexico Military Institute, Roswell	232	6⅝	....
Parsons, R. M., lot 5, block 54, west side Roswell	245	5⅝	675
Patterson, J. F., lot 1, block 42, west side Roswell	260	3	250

[a] Mainly estimated.

Partial list of artesian wells in Roswell district, New Mexico—Continued.

Name of owner and location.	Depth.	Diameter.	Yield.[a]
	Feet.	*Inches.*	*Galls. per minute.*
Peck, J. C., NE. ¼ SW. ¼ sec. 27, T. 10 S., R. 24 E	333	5⅝	400
Pecos Valley and Northeastern Railroad, Roswell (pressure 12 pounds)	248	5⅝	820
Pettey & Miller, lot 6, block 14, original Roswell	225	6⅝	750
Pierce, F., lot 3, block 10, west side Roswell	264	5⅝	600
Rasmussen, E. P., SW. ¼ sec. 21, T. 11 S., R. 25 E	560	5⅝	....
Ray, J. R., lot 6, block 21, west side Roswell	221	5⅝	600
Read, G. W., lot 9, block 6, original Roswell	224	4	400
Redderson, G., lot 11, block 18, west side Roswell	250	5⅝	600
Ried, C. M., lot 3, block 12, west side Roswell	175	4½	300
Roach T., lot 10, block 21, west side Roswell	250	5⅝	600
Roach, T. S., lot 9, block 21, west side Roswell	240	5⅝	500
Rogers, A. C., sec. 25, T. 10 S., R. 24 E	142	3⅝	2
Rose, I. B., lot 7, block 40, west side Roswell	241	5⅝	600
Ross, F., lot 2, block 3, original Roswell	245	5⅝	500
Roswell Wood and Hide Co., lot 7, block 18, original Roswell	262	4½	660
Roswell (town):			
Block 23, west side	163	5⅝	500
Block 41, west side	260	5⅝	600
Block 47, west side	270	5⅝	600
Seay, E.:			
Lot 8, block 38, west side Roswell	205	5⅝	500
Lot 11, block 38, West Roswell	170	4½	400
Sheridan, C., lot 7, block 7, original Roswell	250	5⅝	580
Skipwith, J. H., lot 12, block 8, original Roswell	249	5	500
Slakey, H. B., lot 9, block 57, west side Roswell	218	5⅝	500
Slaughter, C. C., sec. 34, T. 10 S., R. 24 E., Center	275	5⅝	550
Slaughter, G., Thurber's addition, Roswell	225	5⅝	460
Smith, L. R., SW. ¼ NW. ¼ sec. 27, T. 10 S., R. 24 E	330	7⅝	300
Smock, W. S., lot 4, block 50, west side Roswell	235	5⅝	600
Spurlock, SW. ¼ sec. 31, T. 11, S., R. 24 E	917	6⅝	324
Stansell, C. N., NE. ¼ SW. ¼ sec. 11, T. 11 S., R. 24 E	340	7⅝	350
Stevens, L. A., lot 11, block 19, original Roswell	220	5⅝	360
Sutherland, lot 5, block 27, original Roswell	300	5⅝	660
Tipton, W., lot 19, block 6, South Roswell	300	5⅝	....
Totsek, S., lot 6, block 42, west side Roswell	238	5⅝	600
Veal, G. F., lot 10, block 5, original Roswell	361	5⅝	600
Waldron, C. E., lot 11, block 22, west side Roswell	240	5⅝	600
Wallace, J. A., lot 5, block 39, west side Roswell	155	5	[illegible]00
Warren, J. R., lot 1, block 23, west side Roswell	150	4	200
Waskom, A. B., SW. ¼ sec. 32, T. 10 S., R. 25 E	560	6⅝	756
Wells, W. F., lot 1, block 1, Roswell	230	5⅝	660
Whiteman, C., lot 1, block 6, Thurber's addition, Roswell	170	5⅝	400
Wilkerson, W. G., lot 6, block 57, west side Roswell	234	5⅝	580
Wilson, B., lot 8, block 44, west side Roswell	235	5⅝	600
Woodruff & Hedgecoxe, lot 13, block 15, original Roswell	205	5⅝	660
Wyllys, G. L., lot 7, block 58, West Roswell	249	5⅝	780
Yater, B. M., lot 7, block 26, original Roswell (pressure about 7 pounds)	203	5⅝	750

[a] Mainly estimated.

Hagerman district.—In the immediate vicinity of Hagerman there are a few flowing wells, but about 8 miles north, near Dexter and in the lowlands east of Pecos River, there are several. They vary in depth from 300 to 1,000 feet, and the beds penetrated differ somewhat from those of the Roswell district. In the lowlands of Pecos Valley flows of moderate

yield are obtained in soft sandstones at depths of 300 to 500 feet, but on the higher slopes to the west the main flow occurs in porous limestones 800 to 1,000 feet below the surface. The Hedgecoxe well, about 1 mile southeast of Dexter, is 960 feet deep. The main flow occurs in a porous limestone underlying red sandstone 60 feet thick, which is overlain by unconsolidated material.

The following records of wells were furnished by the drillers:

Typical deep borings in Hagerman district, New Mexico.

	Feet.
Record of the Hedgecoxe well, near Dexter:	
Soil and gravel	0– 19
Coarse sand	19– 71
Quicksand	71– 271
Limestone	271– 273
Red sandy clay	273– 323
Yellow clay	323– 343
Limestone	343– 345
Quicksand	345– 545
Limestone	545– 551
Blue clay	551– 601
Quicksand	601– 651
"Shell rock"	651– 653
Alternating layers of sand, silt, and clay	653– 800
Coarse gravel	800– 806
Red sandstone	806– 866
Porous limestone	866– 960
Record of Widdeman well:	
Soil	0– 20
Gravel	20– 55
Quicksand	55– 105
Alternating beds of clay and gypsum	105– 360
Sand	360– 440
Red sand with layers of clay and one 25-foot layer of gypsum near the middle	440– 800
Limestone	800–1,000
Record of Cummins well:	
Soil and gravel	0– 40
Sand	40– 44
Clay	44– 60
Gravel	60– 65
Rock, clay, and sand in alternate layers	65– 105
Clay and sand	105– 165
Red sand	165– 550
Coarse red sand and clay in alternate layers	550– 820
Limestone	820– 840
Partial record of town well at Hagerman:[a]	
Soil	1– 12
Conglomerate	12– 22
Sand	22– 32
Clay	32– 60
Alternating beds of coarse sand and gravel	60– 535
Gypsum and red sandy clay in alternate beds	535– 610
Gypsum	610– 630
Red clay and sand	630– 675
Hard gypsum	675– 732
Hard, gray sandstone	732– 735
Gypsum	735– 745
Red clay and sand	745– 750
Gypsum	750– 760

[a] Boring in progress at time investigation was made.

A. RASMUSSEN'S WELL, EAST OF SOUTH SPRING, NEW MEXICO.

B. WIDDEMAN'S WELL, NEAR DEXTER, N. MEX.

Partial record of H. H. Sigman's well near Lake Arthur:[a]

	Feet.
Soil and conglomerate	0– 5
Hard gypsum (first flow at base)	5– 130
Alternating strata of gypsum and red sand	130– 235
Alternating layers of red sand and clay	235– 345
White sand	345– 545
Red sand	545– 600

Partial list of artesian wells in Hagerman district.

Name of owner and location.	Depth.	Diameter.	Yield.[1]
	Feet.	*Inches.*	*Gallons (per minute).*
Calloway, E. H., T. 13 S., R. 26 E	454		20
Carper, J. E., NW. 1/4 NE. 1/4 sec. 28, T. 12 S., R. 26 E	330	8	377
Casiers, T. M., NE. 1/4 NW. 1/4 sec. 7, T. 13 S., R. 26 E	400	6 5/8	351
Clem, J. A., E. 1/2 sec. 11, T. 13 S., R. 26 E	525	7 5/8	517
Criser, F. A., E. 1/2 NW. 1/4 sec. 33, T. 12 S., R. 26 E	500	5 5/8	300
Cummins, J. Q., SE. 1/4 sec. 33, T. 12 S., R. 25 E	860	6 5/8	250
Elliot, I. H	760	4 1/2	
Formwault, SW. 1/4 sec. 31, T. 12 S., R. 26 E	960	6 5/8	848
Forstad, J., NE. 1/4 sec. 13, T. 13 S., R. 26 E	664	7 5/8	25
Geyer	300	5 1/2	
Goodell, S. W., S. 1/2 sec. 15, T. 13 S., R. 25 E	839	8	
Greenfield farm (center), sec. 32, T. 13 S., R. 26 E		5 5/8	
Hagerman (town), NE. 1/4 SE. 1/4 sec. 10, T. 14 S., R. 26 E	760	8	
Hedgecoxe, NE. 1/4 NE. 1/4 sec. 18, T. 13 S., R. 26 E	960	6 5/8	600
Lake Arthur, sec. 20, T. 15 S., R. 26 E	1,000	10	764
Large, Frank:			
Sec. 4, T. 13 S., R. 26 E	375	5 5/8	420
Sec. 4, T. 13 S., R. 26 E	460	7 5/8	599
Sec. 4, T. 13 S., R. 26 E	460	7 5/8	599
Townsley, H. W.:			
NW. 1/4 sec. 4, T. 13 S., R. 26 E	440	5 5/8	
NW. 1/4 sec. 4, T. 13 S., R. 26 E	450	5 5/8	
Walters, L., SE. 1/4 sec. 14, T. 13 S., R. 26 E	505	5 5/8	310
Widdeman, NW. 1/4 sec. 5, T. 13 S., R. 26 E	1,000		
Wilson, P., NW. 1/4 sec. 18, T. 13 S., R. 27 E	620		20
Winchell, N. J., SE. 1/4 SW. 1/4 sec. 30, T. 13 S., R. 26 E	1,025	8	880

[1] Mainly estimated.

EDDY COUNTY.

Artesia district.—The Artesia district comprises the northern portion of the area of flow included in Eddy County. The formations encountered in boring a deep well near Artesia differ somewhat from those in other parts of the Roswell basin. According to well records they consist for the first 500 to 700 feet of unconsolidated beds of sand, gravel, and clay, which by their loose texture frequently offer considerable difficulty in well construction. Beneath these beds there are alternating layers of red and gray sandstone, clay, and gypsum lying on a series of porous limestones, clays, and sandstones, in which the strongest artesian flows occur. A number of records of deep borings around Artesia, as reported by the well drillers, are here given:

[a] No satisfactory record, particularly of the lower part, could be obtained of this boring, which was originally 1,000 feet deep. There is probably some defect in the casing of the well, for, according to the latest reports, the lower part of the pipe appears to be clogging up with sediment, and there is a perceptible decrease in the pressure of the flow. The best information which could be obtained concerning the formations penetrated in the upper part of this well is here given.

Typical deep borings in Artesia district, New Mexico.

	Feet.
Record of the J. C. Hale well, 1¼ miles southeast of Artesia:	
Soil	0- 10
Red clay	10- 30
White, coarse sand	30-100
Fine sand	100-120
Bluish clay alternating with sandy layers	120-375
Red clay with layers of gravel	375-540
White sand	540-550
Yellow sand	550-556
Red, sandy clay	556-581
Limestone	581-585
Red, sandy clay alternating with layers of gravel	585-745
Gravel	745-751
Hard limestone	751-760
Limestone and red clay	760-794
Hard and soft light-colored limestone with layers of sandstone	794-820
Soft, red sandstone	820-830
Hard, porous limestone and red clay in alternate succession, the limestone predominating.	830-850
Record of the J. S. Majors artesian well, 2 miles north of Artesia:	
Loamy soil	0- 6
Bowlders	6- 15
Concretionary conglomerate	15- 40
Rock	40- 62
Soft sands	62- 68
Rocks and bowlders	68- 70
Gray sand	70- 72
Soft clay	72-160
Moderately hard rock	160-174
Red, sticky clay	174-210
Sticky clay and gravel	210-240
Coarse, white sand	240-275
Clay and gravel	275-290
Soft rock	290-295
Clay	295-310
Red quicksand	310-320
Red clay	320-357
Soft rock	357-360
Soft clay (First flow yielding about 10 gallons per minute)	360-420
Hard rock	420-428
Clay and gravel; some sand	428-460
Clay and sand	460-542
Soft rock and clay	542-560
Tough, red clay	560-598
Hard rock	598-600
Hard clay	600-617
Hard rock	617-628
Red clay	628-630
Soft rock	630-634
Hard rock	634-640
Sand and clay	640-665
Soft rock, clay, and sand	665-700
Quicksand	700-704
Hard rock (limestone; second flow at base)	704-714
Alternating strata of soft rock and clay	714-770
Soft and hard rock in alternate layers	770-795
Very hard rock (limestone)	795-798
Clay and soft rock	798-812
Extremely hard rock (limestone)	812-820
Rock, increasing in hardness	820-823
Record of the Hodges & Venable artesian well, Artesia:[a]	
Soil	0- 10
Bowlders and clay	10- 19
Concrete rock	19- 26

[a] In this well flows were obtained at the following depths: First flow, 450 feet; second flow, 648 feet, third flow, 785 feet; fourth flow, 802 feet.

A. ARTESIAN TOWN WELL, AT ARTESIA, N. MEX.

B. SHERMAN'S PUMPING PLANT, NEAR ROSWELL, N. MEX.

Record of the Hodges & Venable artesian well, Artesia—Continued.	Feet.
Loose gravel	26 – 41
Concrete rock	41 – 46
Red clay	46 – 73
Concretionary gravel	73 – 76
Loose gravel	76 – 86
Hard limestone	86 –113
Loose gravel containing water	113 –120
Limestone	120 –130
Red clay	130 –155
Red clay alternating with conglomerate	155 –185
Alternating strata of concretionary conglomerate and red clay	185 –250
Red clay	250 –350
Alternating layers of red, sandy clay and sandstone	350 –545
Limestone, with an occasional layer of red clay, very hard at base of series	545 –840
Record of the J. B. Barnes artesian well, 12 miles southwest of Artesia:	
Soil	0 – 6
Bowlders and gravel	6 – 13
Yellow clay and gravel	13 – 53
Red clay	53 –153
Quicksand	153 –157
Red sand and soft sandstone	157 –177
Soft, yellowish sandstone	177 –227
Hard limestone	227 –267
Red, sandy clay alternating with soft red sandstone, which gives place to porous limestone in the lower half of the series. (First flow)	267 –450
Soft, red sandstone	450 –500
Porous limestone	500 –525
Soft, red sandstone	525 –535
Record of the S. L. Roberts artesian well, at Artesia:	
Soil	0 – 7
Bowlders and gravel	7 – 42
Red, sandy clay containing some gravel	42 –200
Quicksand	200 –260
Red clay	260 –300
Alternating layers of gray sand and red clay	300 –600
Limestone	600 –604
Gypsum	604 –634
Red clay	634 –675
Limestone	675 –679
Red clay	679 –704
Limestone	704 –705½
Red, sandy clay	705½–745½
Limestone	745½–840
Hard limestone	840 –852
Red, sandy clay	852 –880
Limestone, porous	880 –976
Record of the E. N. Heath artesian well, 2 miles southwest of Artesia:	
Soil and clay	0 – 15
Gravel	15 – 30
Yellow clay	30 – 80
Gravel and sand	80 –280
Sand	280 –310
Gravel and sand	310 –340
Hard, red clay	340 –344
Gypsum	344 –346
Conglomerate	346 –366
Sand with thin streaks of gravel	366 –441
Coarse-grained, porous rock	441 –461
Gray sand	461 –481
Red quicksand	481 –631
Rock	631 –641
Red quicksand	641 –691
Hard, gray limestone	691 –715
Red sand rock with streaks of clay	715 –725
Gray limestone, very hard	725 –745

Record of the W. E. Clark artesian well, 4 miles north of Artesia:

	Feet.
Soil	0- 6
Bowlders and gravel	6- 16
Gypsum	16- 76
Gravel	76- 81
Gypsum	81- 90
Concretionary conglomerate	90- 95
Hard gray sandstone	95-106
Red clay streaked with white clay	106-126
Dark-gray sandstone	126-157
Yellow sand	157-200
Hard gray sandstone	200-218
Red sand	218-232
Very hard light-gray sandstone	232-244
Red sand	244-247
Hard red rock	247-250
Red sand	250-268
Hard red rock	268-274
Alternating strata of quicksand and soft red sandstone	274-536
(In this series at 385 feet occurs the first flow; second flow at 475 feet.)	
Very hard limestone	536-540
Red sandstone, medium hardness	540-580

The greatest development in well sinking in this district is around Artesia, where a number of strong artesian flows have been obtained at depths of 800 to 1,000 feet. A partial list of these wells, including their location, depth, and size, is given in the following table:

Partial list of artesian wells in Artesia district.

Name of owner and location.	Depth.	Diameter.	Yield.[a]
	Feet.	Inches.	Galls. per minute.
Artesia (town), NE. ¼ NE. ¼ sec. 17, T. 17 S., R. 26 E.[b]	771	6	
Barnes, J. B., NW. ¼ NW. ¼ sec. 23, T. 18 S., R. 25 E	535	6	1,548
Bruce, J. A., NE. ¼ NE. ¼ sec. 14, T. 17 S., R. 26 E	872	5⅝	562
C. A. P. Cattle Co., SW. ¼ NE. ¼ sec. 23, T. 17 S., R. 26 E	830		
Clark, W. E.[c]	580		
Deiss, J. J., sec. 32, T. 18 S., R. 26 E	570	6	
Gilberts, S. W., SW. ¼ sec. 7, T. 18 S., R. 26 E	813	6	320
Gilliland, J. W., SE. ¼ sec. 9, T. 18 S., R. 26 E.[d]	826	6	
Hale, J. C., NW. ¼ SE. ¼ sec. 15, T. 17 S., R. 26 E	850	6	1,168
Harris, N. T., SW. ¼ SW. ¼ sec. 14, T. 16 S., R. 26 E.[c]			
Heath, E. N., SE. ¼ sec. 18, T. 17 S., R. 26 E	746	6⅝	
Hodges & Venable, SE. ¼ NW. ¼ sec. 23, T. 18 S., R. 25 E	840	6	1,110
Majors, J. S., SW. ¼ SW. ¼ sec. 31, T. 17 S., R. 26 E	823		
Miller, L. C., SW. ¼ SW. ¼ sec. 8, T. 18 S., R. 26 E	671	6	1,044
Norfleet, A. L., S. ½ NW. ¼ sec. 32, T. 17 S., R. 26 E			
Rawl & Robertson, sec. 5, T. 17 S., R. 26 E	650		
Richey, John, SW. ¼ SW. ¼ sec. 11, T. 16 S., R. 26 E.[b]	835		
Roberts, S. L., SE. ¼ SW. ½ sec. 8, T. 17 S., R. 26 E	976		
Smith, J. Mack, SW. ¼ NW. ¼ sec. 29, T. 17 S., R. 26 E	747	6⅝	1,725
Smith & Beckman, sec. 17, T. 17 S., R. 26 E	881		
Stanford, L. G., NE. ¼ sec. 34, T. 18 S., R. 26 E	797	6	
Walterschied, W. M., E. ½ SW. ¼ sec. 8, T. 17 S., R. 26 E	795	6	

[a] Mainly estimated. [b] 92½ pounds pressure. [c] Incomplete. [d] 72½ pounds pressure.

McMillan district.—This district includes the area in the vicinity of McMillan and the valleys of North and South forks of Seven Rivers. Near McMillan the Walters & Shavers and the Lakewood Townsite companies' wells have strong flows from the porous limestone at depths of about 800 feet. The records of these wells indicate that the unconsolidated

sediments are about 250 feet thick and that the limestone division occurs 500 to 600 feet below the surface. The records of these wells were supplied by the drillers as follows:

Typical deep borings in McMillan district, New Mexico.

	Feet.
Record of the Walters & Shavers artesian well at McMillan:	
Soil	0– 6
Coarse gravel	6– 13
White clay	13– 33
Coarse sand and gravel containing water	33– 43
White chalky rock	43– 70
Very hard gray sandstone with layers of gravel	70–170
Hard flinty rock	170–177
Red clay and coarse gravel in alternate succession	177–235
Light-colored sandy clay	235–250
Red clay	250–254
Alternating strata of gypsum and red clay	254–370
Hard gypsum	370–393
Series of gypsum alternating with red clay	393–440
Alternating layers of white gypsum and red sandstone	440–500
Red sand and hard sandstone in alternate layers 2 feet thick	500–650
Hard white limestone	650–800
Extra hard limestone	800–820
White limestone becoming softer. (Flow of about 300 gallons)	820–845
Record of the Lakewood Townsite Company artesian well at McMillan:	
Loam and gravel	0– 49
Soft gypsum in strata 5 to 6 feet thick	49– 80
White chalky rock	80–120
Sandstone and gypsum in alternating layers	120–135
Pure white gypsum, moderately hard	135–200
Very hard white gypsum	200–450
Soft rock resembling shale	450–490
Alternating layers of hard and soft white rock containing a few thin layers of sandstone. (First flow at 770 feet, second flow at 810 feet)	490–863
Very soft, white rock	863–877
Alternating layers of soft and hard limestone	877–880

In Seven Rivers Valley wells are generally shallow, ranging in depth from 150 to 300 feet, and the flows so far have been obtained from the unconsolidated rock. It is probable, however, that wells sunk to a sufficient depth in this region would obtain flows from the limestone division. A partial list of the wells in the McMillan district is given in the following table, and their location is shown on Pl. VI:

Partial list of artesian wells in McMillan district.

Name of owner and location.	Depth.	Diameter.	Yield.
	Feet.	*Inches.*	*Galls. per minute.*
Brogden, J. C.:			
SE. ¼ SE. ¼ sec. 15, T. 20 S., R. 25 E	305	5⅝	573
Sec. 21, T. 20 S., R. 25 E	150?	5⅝	253
Boyd, G. M., SE. ¼ sec. 26, T. 19 S., R. 25 E	549	5⅝	....
Cole, SE. ¼ sec. 7, T. 20 S., R. 25 E	195	6	....
Eatons	400	....	....
Hellyer, W. E	190	6	12
Lakewood Townsite Co., sec. 27, T. 19 S., R. 26 E	885	6	....
McDonald:			
NW. ¼ sec. 8, T. 20 S., R. 25 E	146	5⅝	75
NW. ¼ sec. 8, T. 20 S., R. 25 E	150	5⅝	....
Plott, J. C., S. ½ NE. ¼ sec. 26, T. 19 S., R. 25 E	347	5⅝	....
Walters & Shavers, NW. ¼ NW. ¼ sec. 23, T. 19 S., R. 26 E	845	6	300

PRESSURE OF ARTESIAN WATER.

In connection with the investigation of the geology and underground water relations of the Roswell basin a systematic measurement of well pressures has been carried on. At the time when this investigation was proposed there appeared to be no evidence that the flow was decreasing, but it was feared that the multiplicity of wells within such a limited area would eventually lower the water plane unless greater economy was practiced by the water users. In arranging for the testing and comparison of pressures a number of representative wells were selected at different points throughout the basin, four from Roswell, where many have been sunk in a relatively small area, and others from near Hagerman and Artesia. In making these selections care was exercised to obtain only those which were believed to be representatives of local districts and in perfect condition. In a few instances, however, defective pipes were discovered after the first monthly pressure had been recorded. Careful measurements were taken of these wells each month under uniform conditions so far as possible. The result of this investigation extending over a period of twelve months is shown in the following table:

Record of periodic pressure measurements in pounds per square inch, of artesian wells in the Roswell artesian basin, New Mexico, for year ending May 31, 1905. [a]

No.	Name and location.	June.	July.	August.	September.	October.	November.	January.	February.	March.	April.	May.	Total loss or gain.
	ARTESIA DISTRICT.												
1	Gilliland,[b] SW. cor. SE. ¼ sec. 19, T. 18 S., R. 26 E.	83	82	80	79	80	79	74	74	72½	69	69	−14
2	Hale,[c] NW. ¼ SE. ¼ sec. 15, T. 17 S., R. 26 E.	88	87	87	84	84	82	80	81	77½	77½	77½	−10½
3	Hodges & Venable,[b] middle of west line SE. ¼ NW. ¼ sec. 23, T. 18 S., R. 25 E.	31½	31½	30½	30	29	27	25	25½	24	21	21	−10½
4	Norfleet,[b] NW. cor. of S. ½ NW. ¼ sec. 32, T. 17 S., R. 26 E.	....	....	62½	61	61	58	55	56	54½	53	53	− 9½
5	Richey,[b] SW. ¼ NE. ¼ sec. 14, T. 16 S., R. 26 E.	....	....	....	....	....	95½	92	94	92½	91	91	− 4½
	HAGERMAN DISTRICT.												
6	Greenfield farm,[d] sec. 32 (center), T. 13 S., R. 26 E.	58	58	57	57	55	53½	53	53	54	....	....	....
7	Sigman, H. H.,[b] NW. ¼ sec. 20, T. 15 S., R. 26 E.	....	....	....	....	....	41	33	30½	....	25	27	−14
8	Widdeman, A. J.,[b] SW. ¼ SW. ¼ sec. 5, T. 13 S., R. 26 E.	....	40	40	40	38	41	41½	39½	39	39	39	− 1
	ROSWELL DISTRICT.												
9	Hagerman, J. J.,[b] near center of west line NW. ¼ SE. ¼ sec. 13, T. 11 S., R. 24 E.	13	13	13	13½	13⅓	13⅓	13⅓	13⅓	14	13⅓	13½	+ ½
10	Hamilton,[b] lot 12, block 14 (original townsite), SW. ¼ SW. ¼ sec. 33, T. 10 S., R. 24 E.	6⅔	6⅔	7⅔	7	7	7⅔	7	7⅔	8	8	8	+ 1⅓
11	McClenny,[e] SE. ¼ SE. ¼ sec. 35, T. 10 S., R. 24 E.	16⅔	16⅔	20	20	20	21	20	21½	22	21½	21½	+ 4⅚
12	Parsons,[b] lot 4, block 54 (west side), NE. ¼ SE. ¼ sec. 32, T. 10 S., R. 24 E.	7	7	7	7	7	7	7	7½	8	8	8	+ 1
13	P. V. and N. E. roundhouse,[f] NE. cor. NW. ¼ SW. ¼ sec. 33, T. 10 S., R. 24 E.	12	10	10	12	12	12	12	13	13	13	13	+ 1
14	Rasmussen,[b] SW. ¼ NW. ¼ sec. 21, T. 11 S., 25 E.	31	31	31	31	31	32½	33	31	31½	31½	31½	+ ½
15	Yater,[b] lot 7, block 26 (original townsite), NE. ¼ SE. ¼ sec. 32, T. 10 S., R. 24 E.	7	7	7	7	7	7	7	7	10	....	10	+ 3

[a] No measurements were obtained for December.
[b] Casings of Nos. 1, 4, 5, 7, 9, 10, 12, 14, and 15 were in perfect condition, or apparently so; slight leakage at valve of Nos. 1, 3, and 8.
[c] Decrease in pressure may be due to escape of water into a higher artesian horizon, which is reached by a shallow well not far away.
[d] This is an old well and the casing may be defective.
[e] Low pressures in the months of June and July due to leakage in pipe.
[f] Slight leakage in casing near surface and at valve caused a decrease of pressure in July and August measurements.

In most cases in the Roswell and Hagerman districts, where the wells were in perfect condition, the pressures of the flows appear to be substantially accordant, but around Artesia there are several wells in which the flows have materially decreased in pressure during the last twelve months. Without a thorough knowledge of the conditions under which artesian water is obtained around Artesia the decrease in pressure of some of the strongest flows in that vicinity might at first appear alarming, but a comparison of this district with that of Roswell, where there is no decrease in pressure, introduces many important factors which have a direct bearing on the case.

At Roswell artesian water is obtained at a depth of about 250 feet, and the materials passed through offer practically no difficulty; as a result, very perfect wells are constructed. Then, too, in this region wells have been built for the last decade, and the well driller is so familiar with the conditions that he can predict with a fair degree of accuracy the materials to be encountered in sinking a well. Farther south in the basin, in the vicinity of Artesia, a successful artesian well is not so easily obtained. Here the main flow is reached at much greater depths, which range from 700 to 900 feet, depending on the location. The increased depth is due to the presence of beds overlying the porous limestone series. They consist of red sand and gypsum of the supposed Permian series, and clay, fine sand, and gravel of the unconsolidated deposits. The sands predominate throughout and have often a loose texture familiarly known to the well driller as quicksand. This material is very difficult to drill through because of caving, and in one or two instances it was so troublesome that the owner was compelled to abandon the project. The pressure at the surface in an average well around Artesia is about 80 pounds to the square inch, which means over 400 pounds to the square inch at the bottom of a well 800 feet deep. Such forces are difficult to manage, particularly where exploitation in the region has not been sufficiently extensive to enable the well driller to thoroughly acquaint himself with the nature of the obstacles to be encountered, and make suitable provision for them. The region is also one that offers considerable inducement to the ambitious well driller. As a result, new machines are constantly coming into this field, and the operators, though skilled in the art of well drilling, are entirely unfamiliar with this locality. It can readily be seen that under these circumstances imperfect wells are likely to result. Some of the strongest flows in the basin are and have been unmanageable since their completion, while others owing to unfavorable conditions are not working satisfactorily.

COMPOSITION OF ARTESIAN WATERS.

General statements.—The artesian waters of the Roswell basin are all more or less mineralized, but in only a few cases are the mineral constituents present in sufficient amounts to materially affect the taste or to be deleterious to plant growth. An average sample of the waters of North and South Spring rivers contains 75 parts of soluble matter to 100,000 parts of water. About two-thirds of the total solids consists of calcium carbonate and calcium sulphate, which are regarded as harmless to plants. The more soluble ingredients of the water, consisting of sodium chloride, magnesium sulphate, and potassium sulphate, occur in amounts too small to injure plant growth if the ground is properly

drained. The following analyses of waters of North and South Spring rivers were made by Prof. E. M. Skeats, of El Paso, Tex.:

Analyses of water from springs in North Spring and South Spring rivers.

SAMPLES FROM MARGINAL SPRINGS IN NORTH SPRING RIVER.

[Parts per million.]

	Total solids.	Silica (SiO_2).	Water.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Chlorine (Cl).	Sulphuric acid (SO_4).	Carbonic acid (CO_3).
No. 1	820	15	84.7	122.3	46.8	57.5	93.6	281.9	118.1
No. 2	710	20	96.9	146.6	48.8	8.5	56.4	240.6	116.9
No. 3	700	25.1	65	106.2	45.4	37.5	78.9	242.1	102.0
No. 4	635.6	15	....	126.0	43.5	22.5	67.9	245.6	115.1
No. 5	610	20	14.1	102.2	43.4	30.3	49.6	245.5	104.9
Mean	699.1	19	52.1	120.7	45.6	31.2	69.3	251.5	111.4

SAMPLES FROM MARGINAL SPRINGS IN SOUTH SPRING RIVER.

[Parts per million.]

	Total solids.	Silica (SiO_2).	Water.	Calcium (Ca).	Sodium (Na).	Chlorine (Cl).	Carbonic acid (CO_3).	Calcium magnesium sulphate.
No. 1	700	26.9	49.4	80.9	23.5	46.7	121.6	351
No. 2	730	30.8	50.0	72.1	51.0	63.0	107.9	355.2
No. 3	690	22.3	53.0	76.1	16.8	27.9	114.9	378
No. 4	790	16.0	63.4	72.1	32.1	48.5	107.9	450
No. 5	1,140	50.0	94.0	80.1	62.1	63.7	119.9	670
No. 6	1,070	41.5	85.5	80.1	52.8	81.2	119.9	609
Mean	853.3	31.2	65.9	92.3	44.7	66.2	115.4	468.9

SAMPLES FROM BOTTOM SPRINGS IN SOUTH SPRING RIVER.

	Total solids.	Silica.	Water.	Ca.	CO_3.	Na.	Cl.	Calcium magnesium sulphate.
No. 1	680	27.2	51.8	111	74	18.9	29.1	368.0
No. 2	650	13.4	51.2	106.2	70.8	17.1	26.3	365
No. 3	700	9.6	57.0	106.2	70.8	19.9	30.5	406
No. 4	670	20.5	52.5	106.2	70.8	18.7	28.8	372.5
No. 5	620.8	....	27.8	109.2	72.8	17.3	26.7	367
No. 6	700	50.2	55.0	106.8	71.2	16.9	25.9	374
No. 7	690	38.3	55.0	106.2	70.8	18.0	27.7	374
No. 8	700	41.6	53.9	105.6	70.4	17.5	27.0	384
No. 9	690	45.0	51.0	112.5	75.0	17.5	27.0	362
Mean	678	27.4	50.5	107.8	71.8	18.0	27.7	374

The composition of the artesian water at Roswell differs somewhat from that of North Spring River. The total solids are greater and also the amount of sodium chloride. The following analysis will show the composition of the water from a number of representative wells at Roswell.

Analyses of water from artesian wells at Roswell.

[Individual data. Parts per million.]

Name and date.	Depth.	Temperature.	Total solids.	Silica.	Ca.	CO_3.	Mg.	Na.	Cl.	Calcium magnesium sulphate.
Crowley:	*Feet.*	*° F.*								
April, 1896	155	64.5	1130	48.0	76.1	113.9	....	160.9	247.6	483.5
April, 1897	155	64.5	930	69.5	70.1	94.9	....	114.5	176.0	395.0
Matthews, Tenn., south of	192	69	680	86.5	56.1	83.9	....	44.7	68.8	340.0
Cahoon:										
1895	227	70.5	860	91.0	76.1	113.9	....	92.2	141.8	315.0
1896	227	70.5	790	35.5	71.1	106.4	3.9	96.5	108.0	316.6
Poe, J. W	237	69	930	46.0	76.1	113.9	....	89.8	138.2	466.0
Judge Lea	225	71	810	20.2	76.9	115.1	....	86.6	133.2	378.0
Captain Clark	256	69.25	1,330	123.0	70.1	94.9	....	154.1	236.9	641.0
Miller, H. M	230	....	1,020	72.3	63.1	106.4	5.67	111.5	171.5	487.5
Prager	218	....	1,170	92.8	73.8	110.4	....	106.0	163.0	576.5
Steam laundry	....	....	1,290	182.0	68.0	102.0	....	183.6	282.4	472.0
Lea, J. C	331	....	1,160	33.0	70.1	94.9	....	150.0	230.0	572.0

The waters of the larger tributaries of Pecos River from the west, analyzed by Prof. E. M. Skeats, are reported to have the following composition:

Analyses of water of the Hondo, Felix, North and South forks of Seven Rivers, and Penasco rivers.

River and location.	Total solids.	Silica, etc., plus water.	Ca.	Mg.	Na.	CO_3.	SO_4.	Cl.	Temperature.	Remarks.
									° F.	
Hondo (above Pleacho).	1,195	80.7	231.9	59.1	37.1	104.3	622.4	59.5	......	Water fairly clear.
Felix (head spring)	467.2	18.8	107.9	23.9	15.2	125.0	152.0	23.3	64	
South Seven (head spring).	1,320.0	194.9	231.7	74.7	13.8	112.4	670.9	21.3	66.5	
North Seven (head spring).	1,020.0	75.6	164.0	71.8	38.9	102.2	567.7	19.8	......	
Penasco (by Gilberts)	650.0	10.0	136.7	42.8	15.2	107.9	324.3	23.3	......	Trace of hydrogen sulphide.

ORIGIN OF THE ARTESIAN WATER.

The water-bearing formations in the Roswell artesian area outcrop in successive zones on the higher slopes to the west. There they receive their water supply by direct absorption from rainfall and by the sinking of streams (see Pl. IX). The Hondo, Felix, Penasco, and Seven rivers are the most important sources. These streams all rise high on the slopes of the Capitan, Sierra Blanca, and Sacramento mountains, where the rainfall is relatively large. As a result they carry an abundance of water in their upper courses, all of which sinks in the outcrop zone of the porous limestones and the overlying formations and passes underground to the east. After the water has entered these porous formations it is confined by impervious layers of limestone or clay, and under the lower lands to the east it is under considerable pressure.

AMOUNT OF ARTESIAN WATER.

It is difficult to make even an approximate estimate of the total amount of artesian water available in the porous formations underlying the Roswell artesian area. We do not know definitely how much water is absorbed by the permeable rocks in their western outcrop, and we are unable to calculate the amount which escapes through springs and by underflow along Pecos River.

The area drained by the larger western tributaries of Pecos River comprises in all about 4,000 square miles. It lies along the east slopes of the Capitan, Sierra Blanca, and Sacramento mountains. The location and extent of the combined watersheds of all streams supplying water to the underlying formations of the Roswell basin is shown in Pl. IX. The annual precipitation for this general region is comparatively large, ranging from 10 to 20 inches. The mean annual precipitation at Fort Stanton, N. Mex., which lies in the area drained by Hondo River, is about 15 inches. The average for seventeen years prior to 1891 was 19 inches, but from 1901 to 1903, inclusive, the annual rainfall was far below the average. The following table shows the result of observations through a period of nearly five years, ending with 1904:

Monthly and annual precipitation, in inches, at Fort Stanton, N. Mex.

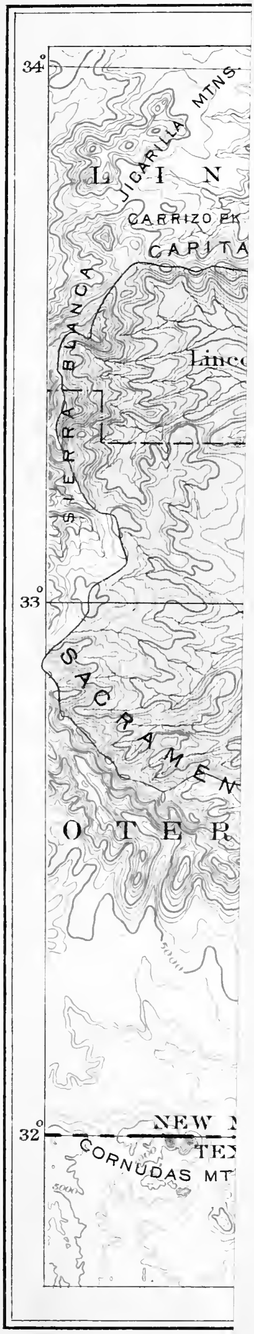
Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1900	......	......	0.48	0.90	1.09	1.63	1.98	2.18	6.06	1.43	0.40	0.36	......
1901	0.10	......	......	0.90	0.64	1.34	......	1.85	2.00	1.76	2.85	0.95	......
1902	0.05	0.38	0.22	0.00	1.88	0.24	2.28	1.87	0.48	1.81	0.16	0.57	9.94
1903	0.36	0.75	0.17	0.20	0.38	3.41	0.62	1.55	1.55	0.48	0.00	0.05	9.52
1904	0.02	0.10	0.03	0.15	0.14	......	2.87	2.92	6.06	2.68	0.08	0.35	......

At Lower Penasco, situated on the headwaters of Penasco River, the mean annual precipitation is about 18 inches, as is shown by the following table:

Monthly and annual precipitation, in inches, at Lower Penasco, N. Mex.

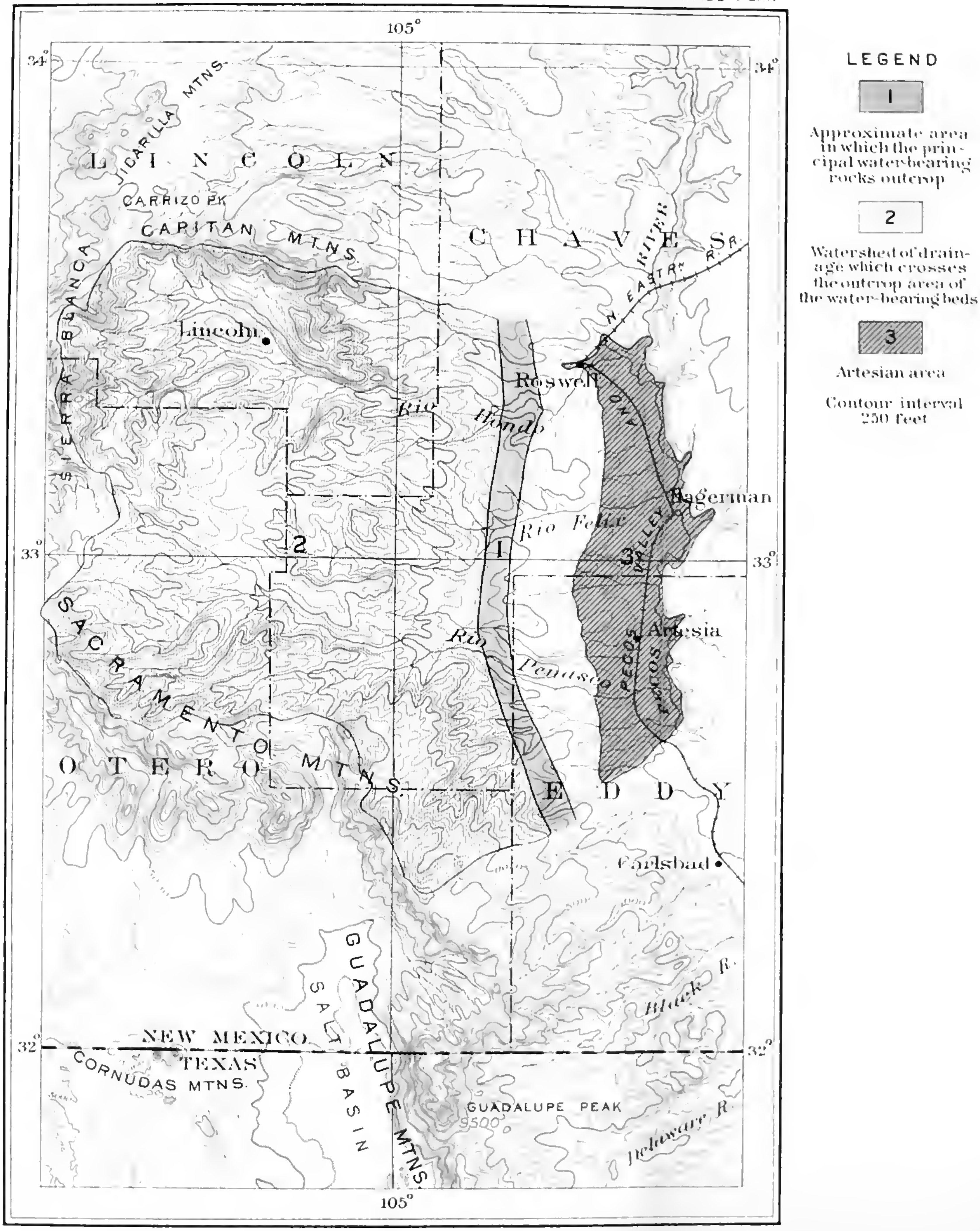
Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1896	0.80	0.40	0.10	T.	T.	2.05	3.56	1.38	1.57	6.01	T.	0.40	16.27
1897	1.40	T.	......	0.50	0.85	0.55	5.60	3.15	1.80	1.05	0.10	0.25	......
1898	0.60	0.25	0.10	1.65	0.70	1.80	7.40	4.00	1.15	T.	0.30	2.40	20.35
1899	T.	0.20	0.35	T.	0	1.70	5.89	1.35	2.90	1.15	1.50	1.05	16.09
1900	0.90	0.30	0.35	0.30	1.70	2.60	4.85	1.95	5.45	1.05	T.	0.60	20.05
1901	......	......	......	0.50	1.15	1.05	6.68	0.97	3.90	......	......	T.	......
1902	0.80	+0.05	0.00	T.	0.35	0.30	......	......	......	......	......	......	......

From the above statements it is apparent that the total amount of water which falls during a year of average precipitation throughout the combined watershed of the Hondo, Felix, Penasco, and Seven rivers is necessarily large. Of course a portion of this water is lost by evaporation and run-off, but a considerable amount is absorbed by the water-bearing rocks and becomes available to the east as artesian water. It has not been practicable in the present investigation to compute the total outflow of all the artesian wells in the Roswell basin, but at a liberal estimate this amount would probably be only a small proportion of the quantity absorbed by the water-bearing rocks throughout their western outcrop area. This is clearly shown by the large number of wells which it has been possible to sink in the town of Roswell without materially diminishing the flows of some of the first wells dug. It is possible that the amount of artesian water available around Artesia is not so great as at



MAP OF

SHOWING T



MAP OF SOUTHEASTERN NEW MEXICO

SHOWING THE GENERAL ARTESIAN CONDITIONS

By C. A. FISHER

0 10 20 30 40 50 MILES

1905

A. HOEN & CO. BALTIMORE

Roswell, but the only evidence of this is the decrease in pressure of some of the wells at Artesia. The combined watershed of the streams lying west of this part of the basin is larger than that of Hondo River, and according to the Weather Bureau records it has a somewhat greater annual rainfall. For these reasons we would expect the formations underlying the southern part of the basin to contain a large amount of water. While there is evidence of a general decrease in flow throughout the Artesia district, it is probable that this diminution is largely due to the clogging of the pipes with sediment, the escape of water along the outside of the tubing from lower to higher horizons, and various other causes which are known to affect the flow of artesian wells.

It is believed that there is no cause for fear that the water supply throughout the northern part of the Roswell basin will give out or become inadequate for all requirements under proper economy of practice. In the region of Artesia and McMillan not enough wells have been sunk to indicate the amount that the water-bearing beds may be expected to yield.

WASTE OF WATER.

There is pressing need for greater econony on the part of the users of well water throughout the Roswell basin. At Roswell a city ordinance regulates the management of all flowing wells, but throughout the remainder of the district no restraint whatever is placed upon the management of the wells, and, with very few exceptions, they are allowed to flow continuously. A small portion of this water is stored in artificial reservoirs, but by far the greater part runs off into pools, evaporates and seeps away on uncultivated lands, or runs directly into Pecos River. In one case noted a ditch leads from the well directly to the river, a distance of one-half mile, and it is not an unusual thing to find water flowing from the wells to low, marshy lands adjacent to the river, where by underflow it soon reaches the main channel. Formerly many of the wells were not even furnished with reservoirs, and the water was carried by laterals directly to the fields during the irrigating season, and at other times was allowed to flow off through wasteways.

Nearly all the wells that are being constructed at the present time in the southern part of the basin are to be furnished with reservoirs ranging in capacities from 6 to 24 acre-feet, which are filled as often as necessary during the irrigating season. Even these commendable provisions are quite ineffectual in the case of wells not provided with valves, as they conserve only a relatively small portion of the total flow. An effort is now being made by a few of the well owners in the vicinity of Artesia to provide each well with a suitable valve, so that, when the water is not in use and the reservoir is full, the flow can be shut down. There is a general prejudice among well owners against shutting off the flow, as they fear that it will decrease the efficiency of the well. It is true that in a few cases wells have been damaged in this way, but where they were properly constructed the per cent injured is very small.

SHALLOW WELLS.

More or less water is obtained throughout the Roswell basin at depths varying from 25 to 200 feet. The water usually occurs in coarse gravel of the unconsolidated deposits. The supply appears to be inexhaustible, and in many cases the water is used for irrigation purposes. Outside the area of flow from Roswell to Hagerman there are a number of wells 75 to 100 feet deep, which furnish 5,000 to 7,000 gallons of water a day. The water is generally pumped with windmills. In the vicinity of Roswell a few deep nonflowing wells are provided with gasoline engines. A gasoline pumping plant on Sherman's farm, at Roswell, is shown in Pl. VIII, *B*.

Bordering the area of flows throughout the Roswell basin there is a zone of irrigable land 3 to 5 miles wide, in which water would probably rise in deep wells to within 100 feet of the surface, so that it could be profitably pumped for irrigation. The approximate limits of this area are shown on Pl. VI.

The following list gives the principal features of a number of shallow wells in the northern part of the Roswell basin:

List of shallow wells in the Roswell basin.

Name of owner and location.	Depth.	Amount pumped per day.
	Feet.	*Gallons.*
Albrecht, E, O., NW. ¼ sec. 32, T. 12 S., R. 25 E	88	....
Altebery, J. R., S. ½ NW. ¼ sec. 28, T. 11 S., R. 23 E	208	....
Bethel, H., W. ½ NW. ¼ sec. 1, T. 17 S., R. 25 E	72	....
Bowers, J. S., SW. ¼ sec. 23, T. 11 S., R. 23 E	132	7,000
Brink, F., E. ½ NW. ¼ sec. 15, T. 11 S., R. 23 E	125	7,000
Clark, J. H.:		
NW. ¼ sec. 18, T. 17 S., R. 26 E	38	....
SE. ¼ SE. ¼ sec. 12, T. 17 S., R. 25 E	100	....
Corn, W. W., SW. ¼ SW. ¼ sec. 35, T. 11 S., R. 25 E	42	....
Costa, N., SE. ¼ SE. ¼ sec. 8, T. 11 S., R. 24 E	27	6,000
Gilbert, C. H., NE. ¼ NE. ¼ sec. 21, T. 11 S., R. 25 E	360	....
Gishwiller, J. A., SW. ¼ sec. 18, T. 11 S., R. 24 E	71	8,000
Hobbs, J. W.	58	....
Hobbs & Hanney, SE. ¼ sec. 2, T. 11 S., R. 23 E	77	5,000
Hortenstein, SW. ¼ sec. 23, T. 12 S., R. 25 E	102	6,000
Miller, F., T. 11 S., R. 23 E	85	2,000
Millheiser, P.:		
SW. ¼ SW. ¼ sec. 7, T. 11 S., R. 24 E	30	3,000
SW. ¼ NE. ¼ sec. 7, T. 11 S., R. 24 E	175	5,000
Paulson, P. O., NW. ¼ sec. 30, T. 13 S., R. 26 E	58	....
Peck, J. C., SE. ¼ sec. 27, T. 11 S., R. 23 E	160	5,000
St. John, J. A., SE. ¼ SE. ¼ sec. 18, T. 11 S., R. 24 E	60	7,000
Saunders, J. P., SW. ¼ NW. ¼ sec. 8, T. 13 S., R. 25 E	155	....
Smith, E. L., T. 11 S., R. 23 E	129	7,000
Stockard, J. W.:		
SE. ¼ SE. ¼ sec. 23, T. 11 S., R. 23 E	150	7,000
NW. ¼ SE. ¼ sec. 23, T. 11 S., R. 23 E	92	6,000
Turner, W. P., NE. ¼ NE. ¼ sec. 7, T. 11 S., R. 24 E	30	6,000
White, G. A., sec. 18, T. 14 S., R. 26 E	84	....
Williams, O. L., NE. ¼ sec. 7, T. 12 S., R. 25 E	103	....

IRRIGATION.

Irrigation has been practiced to some extent in the Roswell basin since the first settlements were made, but prior to 1889 only a few small farms were irrigated. The permanent water supply in the vicinity of Roswell was the first to be utilized. Here a number of small ditches were dug, and by extending these ditches from time to time the present Roswell irrigation system has been developed. The Northern canal system, which irrigates the territory south of Roswell, was built by a development company as a part of a large irrigating project, designed to irrigate Pecos Valley from Roswell to the Texas-New Mexico line.

Roswell system.—A number of ditches have been constructed from the head springs of Middle and South Berrendo and North and South Spring rivers, which furnish water for the land along their valleys. The surplus water of these ditches is directed into the Northern canal to be used for irrigation farther down Pecos Valley.

Northern canal.—This canal extends from Hondo River at a point about 5 miles east of Roswell to near Lake Arthur, a distance of about 35 miles, and irrigates a large district of well-improved farming land in the vicinity of Hagerman. Besides receiving water from

the Berrendo and North and South Spring rivers, the Northern canal is supplied with water to some extent by artesian wells. Though the water of the Northern canal is highly mineralized from the large amount of seepage water which it receives in the vicinity of Roswell, the harmful salts apparently are not present in sufficient quantities to affect plant growth. The following analysis made by Prof. E. M. Skeats shows the average condition of the Northern canal water:

Analysis of Northern canal water.

	Parts per million.
Sodium (Na)	256.1
Sodium and potassium sulphates	230.0
Magnesium (Mg)	50.4
Calcium (Ca)	428.0
Chlorine (Cl)	393.9
Carbonic acid (CO_3)	101.9
Sulphuric acid (SO_4)	349.7
Silica, alumina, and iron ($SiO_2Fe_2O_3Al_2O_3$)	20.0
Water of crystallization	190.0
Total solid	2.020.0

Hondo project.—Preparations are now being made by the Government to store the flood waters of Hondo River for the purpose of irrigating lands along Hondo Valley above Roswell. The location of the proposed reservoir is in a high natural depression on the divide between Blackwater Arroyo and Hondo River. The surface rock in the vicinity is a massive blue limestone, weathering to light gray, underlain by alternate layers of gypsum and red and yellow clay. The bedding was originally uniform, but surface waters have dissolved the gypsum, causing a settling of the beds in the bottom of the reservoir and considerable local distortion around its rim. A number of borings were made with a diamond drill in the bottom of the reservoir, in order to determine the character of the underlying rocks. The following is a record of one of these borings:

Record of diamond-drill boring, Hondo reservoir site, New Mexico.

	Feet.
Clay	0 -11.1
Broken limestone	11.1-22
Clay	22 -25
Cavity	25 -30
Broken rock cavities	30 -64.4
Gypsum	64.4-70.2
Clay	70.2-71.9
Cavity	71.9-73.4
Loose rock	73.4-76.8
Gypsum	76.8-79.8
Clay	79.8-80.2
Limestone	80.2-88.4
Gypsum	88.4-91.8

ARTESIAN IRRIGATION.

The use of artesian water for irrigation in the Roswell area began soon after the first flowing wells were obtained, and it has been gradually increasing ever since. Irrigation from the waters of Hondo and North and South Spring rivers has been practiced, as previously stated, for many years, and the use of artesian water was not resorted to until most of the surface waters of the region had been appropriated. There are now several farms in the vicinity of Roswell that depend entirely on artesian water for irrigation, and to the south nearly all the land included in the area of flow has been filed on with the intention of reclaiming it by artesian irrigation. Many of the farmers in the vicinity of Roswell who have practiced artesian irrigation for several years have obtained results which are highly satisfactory. This has caused considerable interest and enthusiasm among those living farther south in the less developed portions of the basin, and in this region

many large wells are now being sunk, which will be used exclusively for irrigation. Many of these wells are being provided with storage reservoirs, so that a larger amount of water will be available during the growing season.

Among many landowners throughout the area there is a tendency to overestimate the amount of land that can be irrigated from an ordinary artesian well. According to conservative estimates made by irrigators who have had considerable experience in this locality a flowing well with a yield of 450 gallons per minute, provided with a suitable storage reservoir, will irrigate 30 acres of alfalfa or 70 acres of orchard. In order to accomplish this, however, the land must have the proper slope and the soil must be of uniform texture. Alfalfa requires more water than any of the staple crops. Under ordinary conditions 30 inches per year is sufficient, but if the land is irrigated during the winter a larger quantity is required. If this amount of water is properly applied, three or four crops may be cut, the harvesting period ranging from May to the latter part of August. An average yield of alfalfa is 1 ton to the acre for each cutting.

It is difficult to make definite statements regarding the irrigation of orchards in this locality. It is accomplished in many different ways, depending mainly on the age and condition of the trees. In many instances vegetables are raised between the rows of trees, and no additional water is required for the irrigation of the orchard. It is generally sufficient to water an orchard once a month during the summer and once, or possibly not at all, during the winter. About 15 to 20 inches of water a year is required.

CLIMATE.

Temperature.—The climate of the Roswell basin does not differ materially in the prevailing aridity from that of the remainder of southern and eastern New Mexico. The temperature of the region is high, with a low relative humidity. The summers are usually long and hot and the winters mild and pleasant. The maximum temperature is 110° and the minimum seldom falls far below zero. The following tables compiled from the records of the United States Weather Bureau give the mean monthly maximum and minimum temperatures of the Roswell district. The observations extend over a period of ten years, 1895 to 1904, inclusive:

Mean monthly temperature at Roswell, N. Mex.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum	71.6	78.6	85.4	90.1	86.9	101.4	99.2	99.4	97.3	87.5	81.5	74.2
Minimum	6.5	5.4	18.4	26	38.5	49.9	56.8	55	41	28.5	17	7.5

Rainfall.—The average annual precipitation at Roswell is 16.6 inches. The greater part of this amount falls during the months of June and July in frequent showers, which, although often violent, are generally local and of short duration. Only a small percentage of the annual precipitation falls as snow. The following record of the monthly and annual pecipitation at Roswell, extending over a period of ten years, shows considerable variation:

Monthly and annual precipitation, in inches, at Roswell, N. Mex.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1895	0.40	0.48	0.02	0.14	2.31	1.28	4.45	2.99	1.09	2.11	0.85	0.07	16.19
1896	0.60	0.14	0.02	T.	0.12	1.97	1.79	0.40	1.89	5.46	0	0.64	13.12
1897	1.12	0	0.59	1.35	3.76	1.42	2.78	2.94	1.25	:44	T.	T.	15.65
1898	0.26	0.86	T.	0.34	1.03	6.05	6.53	2.99	0.69	T.	0.50	1.37	20.62
1899	0.06	0.15	0.06	0.23	0.27	1.62	4.37	1.21	3.64	0.20	3.21	1.54	16.56
1900	0.96	T.	0.50	0.39	1.62	2.13	2.85	1.25	6.53	3.33	0.17	0.07	19.80
1901	0.21	1.15	0.00	0.97	1.04	0.22	3.04	0.60	1.99	2.21	6.15	0.26	17.84
1902	1.24	0.00	0.83	T.	0.70	1.03	5.52	1.80	3.08	1.36	0.52	0.50	16.58
1903	0.22	0.96	0.10	T.	0.74	4.37	......	......	0.92	T.	0.00	0.00	......
1904	0.16	0.14	0.00	0.07	1.30	1.80	1.23	0.83	5.10	2.67	0.15	0.30	13.75

The heaviest rainfall ever recorded at Roswell was on October 31, 1901, when 5.65 inches fell in one night, causing considerable damage by flooding.

AGRICULTURE.

The general aridity of the climate renders farming without irrigation impracticable except in a few low-lying areas adjacent to Pecos River. In consequence agriculture is restricted to those portions of the valley where water can be obtained from some of the various canals or from artesian wells. The cultivated portions of the basin at present comprise about one-eighth of the total area included in this report, the remainder being utilized for pasturage of cattle—an industry to which the higher lands are well adapted. The chief products are alfalfa, Kaffir corn, wheat, oats, corn, potatoes, Mexican beans, cantaloupes, celery, and a large variety of garden vegetables. Alfalfa and Kaffir corn are perhaps the largest crops and both are consumed in the region. Fruit raising is a growing industry and many large orchards are found in the irrigated district. Peaches, pears, plums, cherries, and other small fruits have a hardy growth and an abundant yield, but the apple crop is the most important. At South Spring there is a large apple orchard, comprising about 600 acres, from which many thousand pounds of apples are shipped annually. Several large apple orchards have been planted during the last five years, and fruit raising seems destined to become one of the most important industries of the district. The seasons are ordinarily of sufficient length to insure the maturity of all cultivated crops.

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